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RADIO IDENTIFICATIONS IN THE NEP DEEP FIELD

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ABSTRACT

We have imaged the AKARI Deep Field with the GMRT radio telescope at 610 MHz, detecting 1224 radio components, which are optically identified with 455 optical galaxies having a mean r' magnitude brighter of 22.5 (to a completeness limit of 25.4 mag), and an average redshift ~ 0.8.

Key words: NEP— FIRC —radio continuum: galaxies — multiwavelength survey

1. INTRODUCTION

The AKARI Deep Field North Ecliptic Pole survey (NEP - Matsuhara et al., 2007; Hwang et al., 2007) was designed to study the star formation history as a function of redshift, and to understand the mass assembly of early type galaxies. Using the Japanese AKARI infrared satellite, we made a deep far-infrared survey close to the NEP covering the high exposure (AKARI observed the NEP during every orbit) part of the deep field. To support this we have made a sensitive radio survey with the Giant Metre Wave Radio Telescope (GMRT) at 610 MHz covering the AKARI Deep Field (Takagi et al., 2012; White et al., 2015 *in preparation*), which, by cross-correlating the radio components with AKARI source catalogues, is used to identify radio loud galaxies and active galactic nuclei.

2. RADIO SURVEY

GMRT observations were obtained as part of a 2-beam mosaic of the NEP region observed during June 2011, covering an area of 1.5 degree^2 around the NEP. The synthesised half power beam width of the data was $4''$, the half power beam-width of the primary beam is $43'$, and the rms noise level was 20 μJy per beam. Figure 1 shows the map observed towards the North Ecliptic Pole using the GMRT radio telescope at 610 MHz.

The GMRT data was compared with the 1400 MHz survey of the NEP by White et al. (2010) with the Westerbork Synthesis Radio Telescope (WSRT) survey which had a resolution of $17\times15.5''$ and sensitivity 21 μJy per beam, and areal coverage of 1.7 degree^2. The GMRT survey has the advantage of sampling sources a factor $\sim$2 times fainter, assuming that the average spectral index for extragalactic radio sources scales as $\propto \nu^{-0.7}$, and benefits from a factor of $\sim$ 4 times higher angular resolution. In this paper, results are presented for the 0.6 degree^2 area of the NEP Deep region (Takagi et al., 2012).

Figure 2 shows a montage of images obtained with various telescopes and at various wavelengths (for details of the various ancillary data sets used in this Figure please refer to Table 1 of Karouzos et al., 2014). In this example, the displayed WSRT radio source, NEP 175714+662139, has a photometric redshift of 0.604 and r' magnitude of 20.53 (Oi et al., 2014).

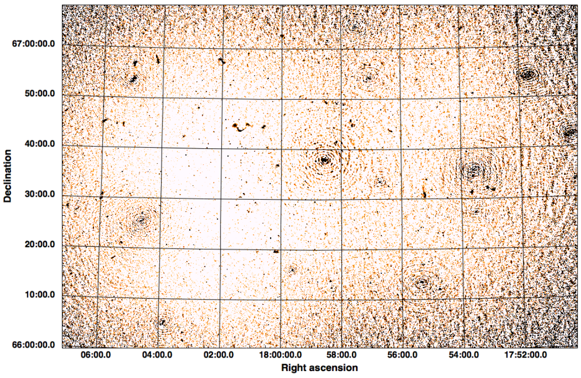

Figure 1. GMRT 610 MHz mosaiced image of the North Ecliptic Pole. 1224 discrete radio components were identified to a 5σ threshold, with the brightest source close to the map centre, NGC6543, The Catseye Nebula, having a flux of 27 mJy per beam. Noise increases at the map edges due to primary beam attenuation.

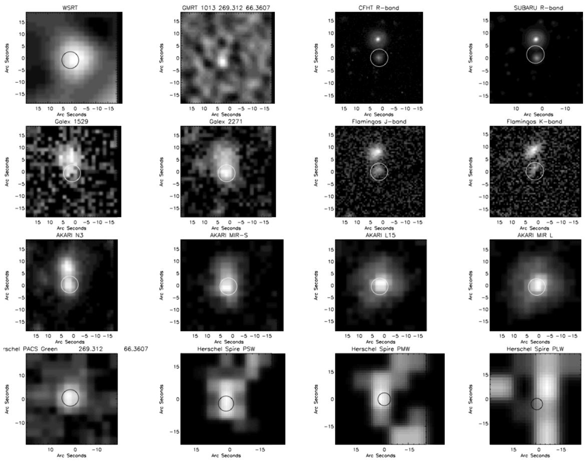

Figure 2. $40'' \times 40''$ images centred on the WSRT radio source NEP 175714+662139. The circle is a nominal $4''$ diameter reference at the position of the WSRT radio source, to show the relative positional accuracy of the various surveys.

3. CROSS-IDENTIFICATIONS

Matching the GMRT catalogue with the photometric redshift catalogue of Oi et al. (2014) for the NEP Deep area. The GMRT source density in the NEP Deep region is 695 radio sources per square degree. We find 455 sources that coincide to within a 2 arc second radius search area. The distribution of the r' magnitudes of the associations is shown in Figure 3.

The mean of the magnitude distributions of r' magnitudes of optically identified galaxies is $\sim$22.5. Based on the r' source density from Oi et al. (2014), the probability that an unrelated and randomly distributed galaxy with $r' = 23$ or brighter lies within the $2''$ diameter radio search box is <3%. Further work is needed to confirm associations with galaxies whose r' magnitudes are fainter than 23, because of the possibility to mis-identify as a consequence of confusion.

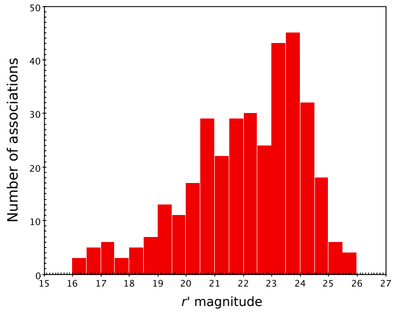

Figure 3. r' magnitudes of the GMRT radio associations in the NEP Deep field.

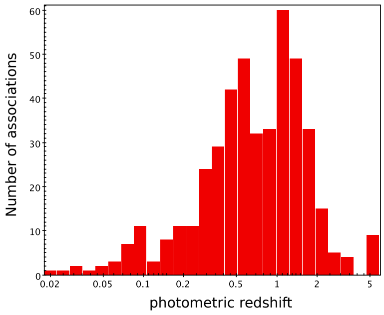

Figure 4. Photometric redshifts of the GMRT radio associations in the AKARI NEP Deep field.

The assigned photo-z or spectroscopic measurements taken from Oi et al. (2014) are shown in Figure 4, where the mean of the redshift distribution peaks at $z \sim 0.8$.

The identified sources from the GMRT radio sample have been examined in Herschel/AKARI colour-colour space as shown in Figure 5.

It is notable that the template colours and redshift tracks follow the data very well, i.e. for the blue star forming track the 10th marker (z=1) is around the point between the z <1 and z >1 sources, as might be expected. The data suggest that log(350μm/250μm) colours > -0.2 preferentially select z >1 objects, and appear better represented by the M82 or LIRG templates rather than the archetypal ULIRG Arp220 SED.

4. CONCLUSIONS

The AKARI North Ecliptic Pole deep field has been imaged using the GMRT telescope at 610 MHz, detecting 1224 radio components. By simple cross-matching with a CFHT r' catalogues, we associated 455 of the GMRT radio sources with r' galaxies down to the optical completeness limit $r' = 25.4$ mag, although the

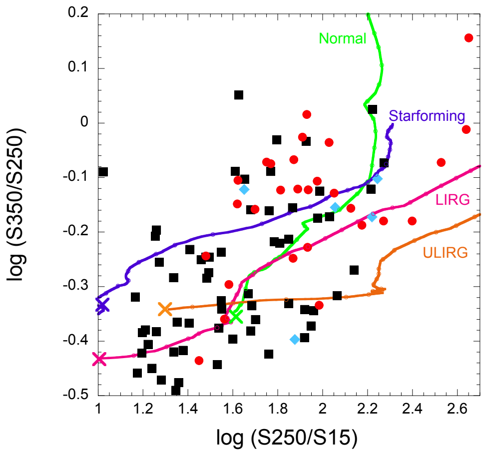

Figure 5. Colour-colour plot for GMRT radio sources. The black squares are sources $z < 1$, red circles $1 < z < 2$ and the (very few), and blue diamonds at $z > 2$. The small dots on the SED tracks along solid lines correspond to increments in $dz = 0.1$ for the given spectral template or either a normal, star-forming (M82), LIRG, or ULIRG (Arp22) galaxy template.

possibility for confusion rises for galaxies fainter than $r' = 23$ mag. The mean value of the r' associations is $r' = 22.5$, and the corresponding mean redshift is 0.8. Using a combination of Herschel and AKARI data we show that log(350μm/250μm) colours > -0.2 preferentially select objects having z >1, and that the SEDs are better fitted by local M82 or LIRG spectral templates.

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